Range-Dependent Inversions for Bottom Acoustic Properties

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LONG-TERM GOAL

To develop an inversion procedure which will estimate the bottom acoustic properties as a function of spatial coordinates.

OBJECTIVES

Investigate the feasibility of obtaining the three dimensional structure of the sediment acoustic properties with the use of fixed source and drifting receivers.

BACKGROUND

In shallow water, the propagation of sound is strongly influenced by the acoustic properties of the sediments. It is therefore necessary to develop capabilities for estimating the ocean bottom acoustic properties. A number of approaches have been proposed for obtaining the compressional wave speed profile, density profile and the compressional wave attenuation profile of the ocean sediments. A method proposed by Rajan et al.[1] is based on a perturbative approach and uses the eigenvalues of the propagating modes as input data for the inversion procedure. The eigenvalues of the propagating modes are determined from field measurements. In a range dependent environment, the modal eigenvalues vary with range. The eigenvalues are dependent on the local properties of the water column and the sediment layers. Therefore by obtaining the local eigenvalues it will be possible to determine the range dependent properties of the bottom. The compressional wave speed profiles and density profiles can be obtained from the eigenvalues. This has been demonstrated in a number of field experiments[2].

APPROACH

In order to obtain the modal eigenvalues as a function of range, we divide the total range into a number of range independent segments and determine the eigenvalues for each segment. High-resolution algorithms such as Music or Esprit[3] can be used to obtain the eigenvalues from short aperture data. We have used Esprit to determine the eigenvalues since this approach does not require searching the entire wavenumber space as required by Music.

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We consider an experimental scenario where the source is fixed and a receiver is carried by a buoy which is allowed to drift in the region of interest. Similar set up was used in the MOMAX experiments conducted by researchers at WHOI. By deploying a large number of buoys a wide area can be covered and rapid assessment of the environment made.

WORK COMPLETED

A. Simulation Study

Figure 1 shows the track of a buoy in the MOMAX experiment. In order to study the feasibility of performing range dependent inversions, the track of a number of buoys were simulated as shown in Figure 2. From this simulated data the field was obtained along horizontal tracks. The horizontal tracks are shown in Figure 3. The characteristics of the environment are shown also shown in Figure 3. The water column 35 m deep was assumed to be homogeneous. The sediment properties changed with range as shown in Figure 3. In medium 1 the sediment the compressional wave speed in the sediment layer was assumed to be 1630 m/s while in the region of medium 2 the top 10 m thick layer had a compressional wave speed of 1610 m/s. The frequency of the source was 100 Hz.

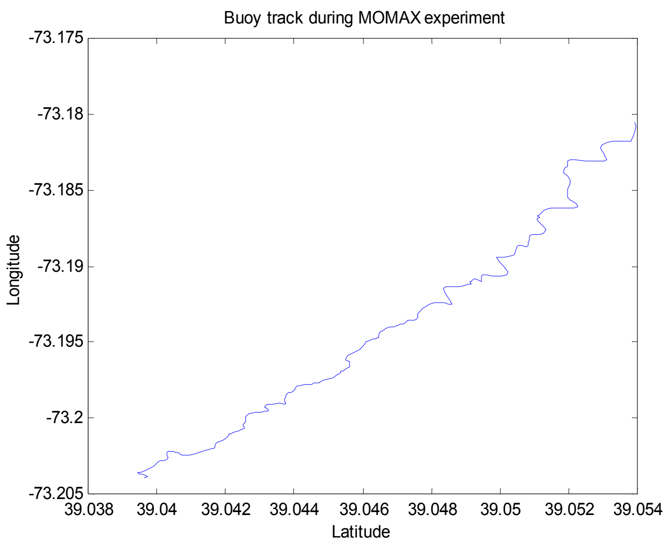

Figure 1. Buoy track during MOMAX.

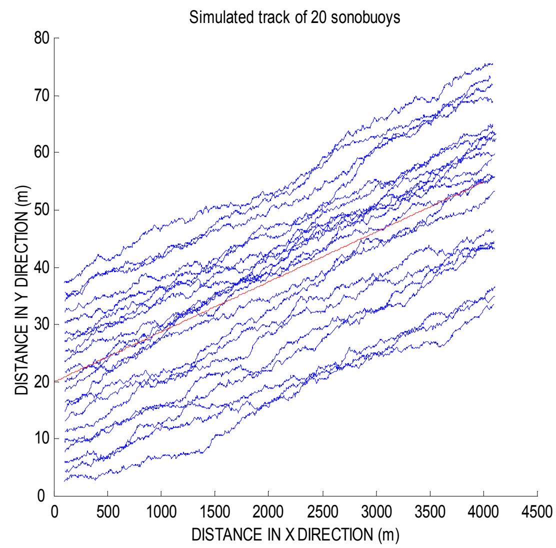

Figure 2. Simulated tracks.

The acoustic data obtained by simulation along each horizontal were analyzed and the evolution of the modal eigenvalues with range were determined using ESPRIT. The evolution of modes with range is shown in Figure 4. This was done for twelve tracks separated from each other by 10 m. The sediment compressional wave speed profiles were obtained as function of position from the modal eigenvalues.

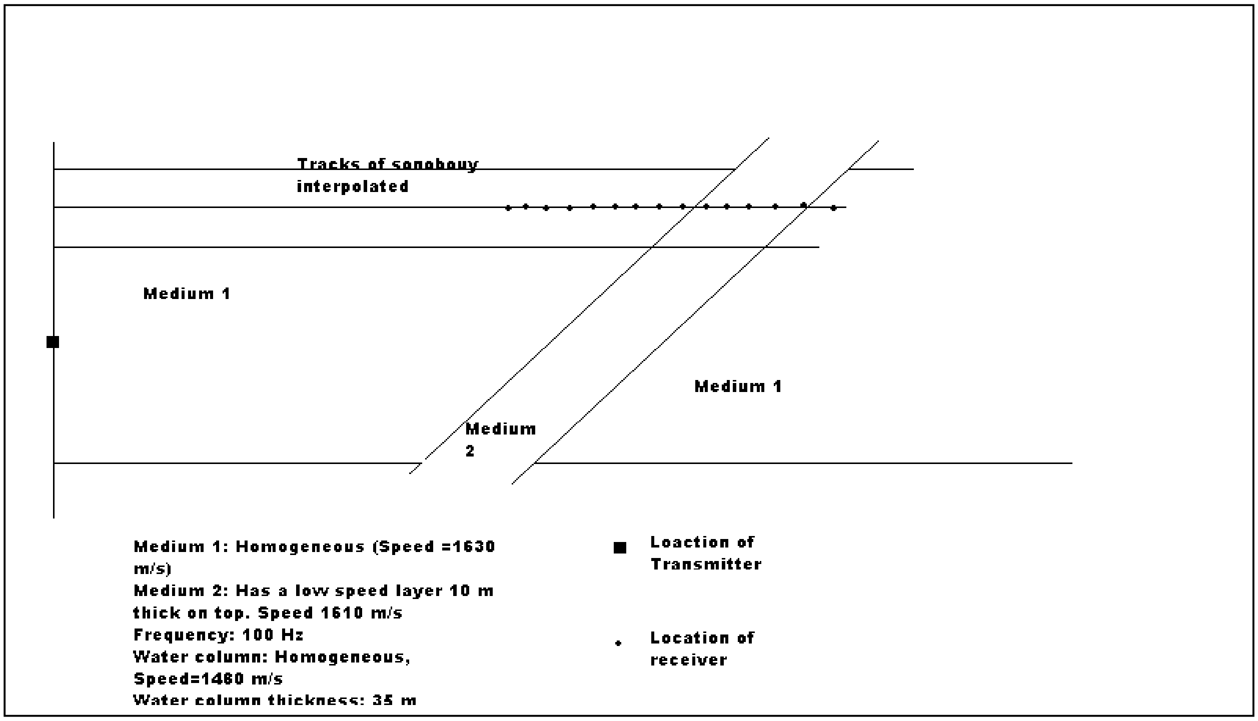

Figure 3. Environment and track data used in simulation study.

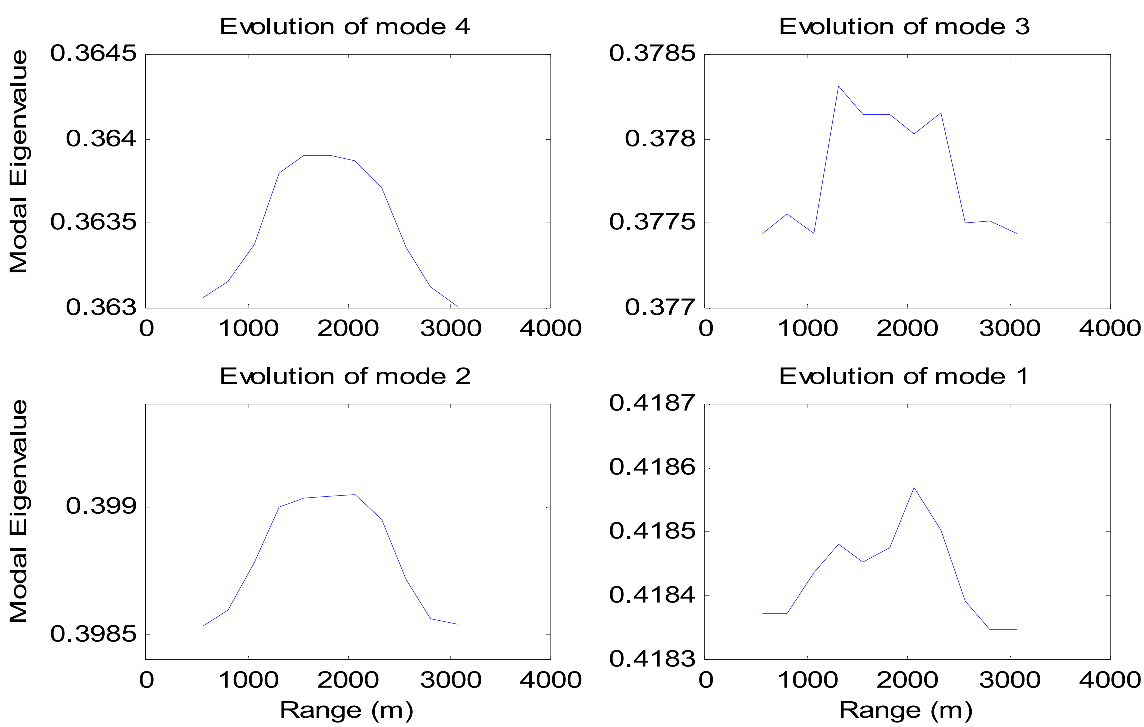

Figure 4. Evolution of modal eigenvalues with range.

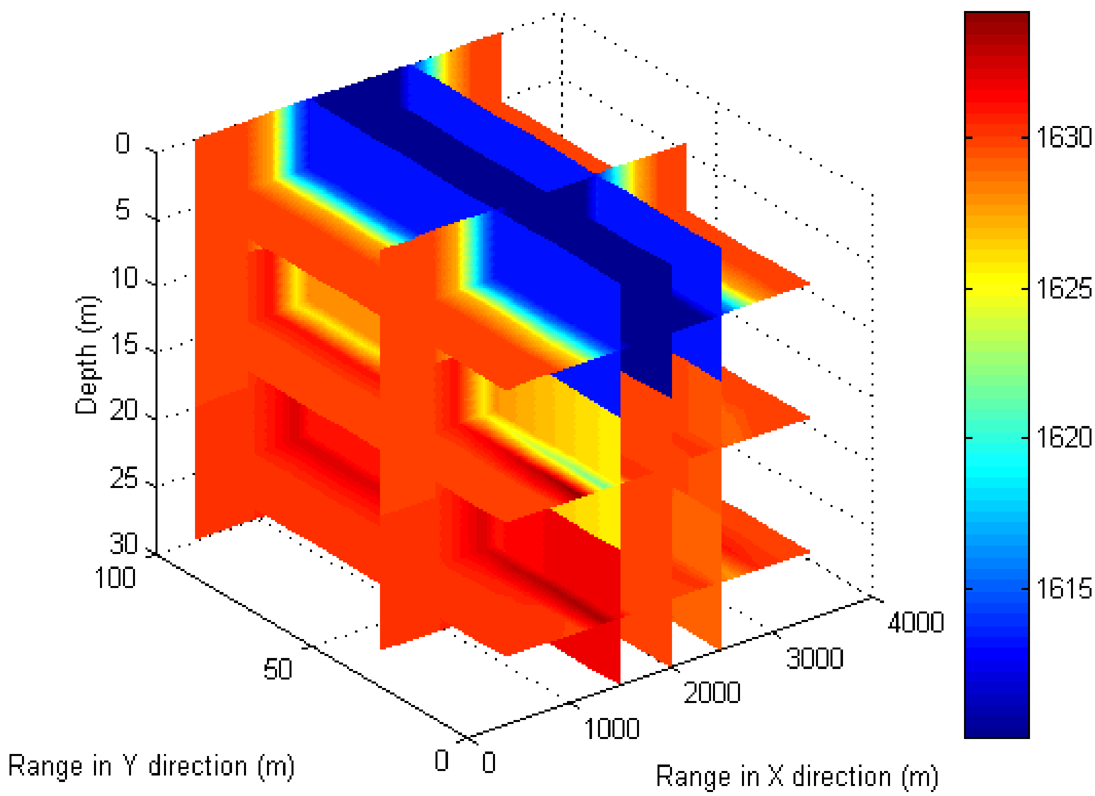

Figure 5. Three-dimensional structure of compressional wave speed.

B. Analysis of Momax data

The analysis of data acquired during MOMAX I experiment is now in hand. Compressional wave speed profile obtained from the inversion of 75 Hz data from one of the buoys is shown in Figure 6. The measure field and the predicted fields are shown in Figure 7. Further analysis of the data is in progress.

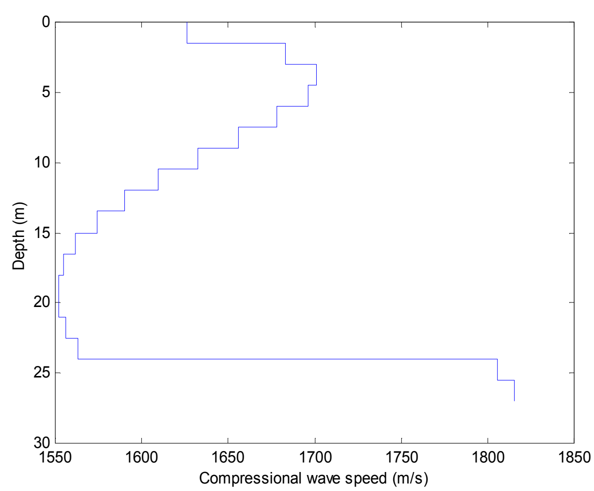

Figure 6. Compressional wave speed profile from Momax data.

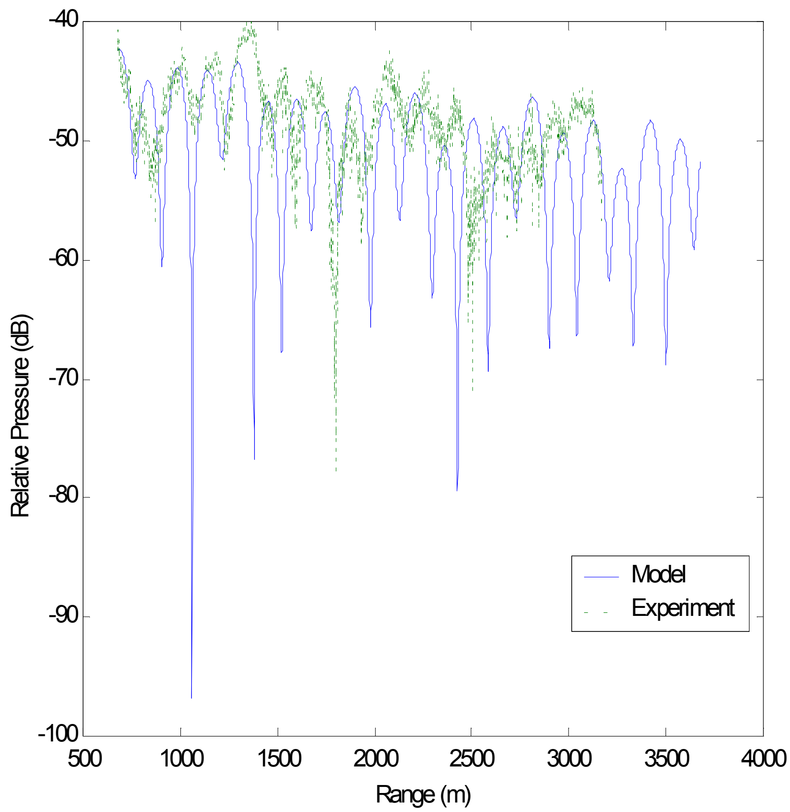

Figure 7. Field predicted by the model and the measured field.

IMPACT/APPLICATIONS

If this approach is successful, it can be used for rapid assessment of the environment. If the source is made broadband, then range dependent inversions using modal dispersion data can be performed. By deploying the buoys and the source from an aircraft covert rapid assessment of environment in enemy territory is feasible.

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3. S. D. Rajan and S. Bhatta, "Evaluation of high resolution methods for estimating modal eigenvalues in a shallow water environment," J. Acoust. Soc. Am., 93, 378-389, 1993.